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Seismic Performance Evaluation of Industrial Junction Tower

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ABSTRACT: Industrial towers are high enough from the ground to carry heavy loads safely. In addition to their own weight, they have to stand up to things like strong winds, earthquakes, and heavy snow loads. For a safe and cost-effective design, industrial towers should be made with both structural and electrical needs in mind. For both static and dynamic analysis, different types of effective elements were used on different parts of the Industrial towers to make a model. Use ETABS to find out more about the static response and stress results of the Industrial towers structure at one static instant time in a vertical and transverse position. Also looked at the free vibrational or modal analysis characteristics of the transmission tower by figuring out its frequencies and mode shapes with ETABS and confirming the finite element-based results with a closed-form solution. At last, a more in-depth study was done on the transient dynamic analysis of a transmission tower using ETABS, with a focus on figuring out how the tower responds to a wind load that changes over time and has different speeds. Design isn't just about figuring out how things work, you should also use your creativity. Art is a skill that comes from having knowledge and using it. Designing structures usually involves guessing the size of the members needed for a given structure and analysing them to see if the stresses and deflection they cause are within the limits set by codes of practise. Structural design can be thought of as the process of putting things in three-dimensional spaces in the best way possible to meet a certain goal. Industrial training is an important part of learning the practical and professional skills that an engineer needs to have. The goal of industrial training is to get experience in engineering fields that are used in real life. Through this, one can learn more about engineering practise in general and get a sense of common and possible problems.

KEYWORDS: ETABS, Industrial Towers, Dynamic Analysis, Static Analysis.

I. INTRODUCTION

Since the beginning of time, the earth has been shaking. Earthquakes are rare forces that can affect buildings, but they can happen at any time. A series of vibrations are made when sideways forces move through the ground. These vibrations are turned into dynamic loads or inertial forces that make the ground and structures on it move in a complicated way. Buildings and other structures could be damaged by these dynamic loads or inertial forces. In places where earthquakes aren't a big deal, the standard way to design structures is to make sure that they can stand up to static (gravitational) and dynamic (like wind) loads in an elastic way. But if this design method had to be used in situations where earthquakes had to be taken into account, it could lead to designs that use too much energy and aren't cost-effective. If you do this, the masses will be bigger, which means the seismic forces will be bigger. Seismic design is based on the use of building techniques, types, and criteria that are used to design and build structures that are likely to be affected by earthquakes. The building may fall down or be destroyed because it was not built to withstand earthquakes well. According to building codes, structures are built so that they don't fall down and can withstand the kind of earthquakes that are likely to happen where they are built. Seismic design helps the building have the right stiffness, strength, shape, and ability to bend. The basic requirements of seismic designs depend on the ground, as well as the type of structure, where it will be built, and how seismic design and criteria will be applied. Seismic-resistant construction is when the seismic design and building codes are used to make sure that buildings can stand up to earthquakes.



India's energy sector has grown a lot in the past few years. India gets about 80% of the electricity it needs from coal thermal power plants. The efficiency of thermal power plants is based on how well their infrastructure and parts work together. The steel junction tower is thought to be the most important part of a coal thermal power plant because it has to deal with complex structural arrangements and loads coming from different directions. So, it is important to study how the steel Junction tower responds and works. There isn't a lot of written information about the complex steel junction tower. A thorough review of the literature showed that there were many studies on steel building frames that were subjected to different types of static and dynamic loading, but there were no publications on complex steel junction towers. When there are so many images of broken buildings after a big event like an earthquake, it might seem like a simple task to find out where the damage is. Many times, serious damage to a building's structure is hard to see, but it has become clear in many steel-framed buildings. A lot of moment-resisting frames had serious damage in the areas where the beams met the columns. This damage wasn't discovered until expensive inspections were done, which required taking off the wall cladding and fireproofing. Many times, modal testing has been used to try to find and describe damage to a structure that was caused by an extreme event like an earthquake, wave force, or corrosion. It is a growing field of study because problems that can't be seen in structures like offshore rigs or buildings where the structural members are covered by cladding can pose serious risks of collapse if they aren't found and fixed in time. Inspection methods can be very expensive, and analytical and measuring tools can help a lot to narrow down the area where damage could happen. Even though damage detection seems like a very promising technique, it is still very hard to tell what kind of damage is in a complex structure unless it is very bad. In this paper, the modal parameters of a steel junction tower are studied before and after the structure has been damaged by earthquakes, corrosion, or other extreme events. In this numerical study, STAAD Pro V8i SS6 was used to do a modal analysis on the steel junction tower FE model. The FE models are looked at and compared with and without damage in the column at key points. The results of the modal analysis are looked at to find out how the modelled steel junction tower responds globally.

1.1 Objectives

The steel structure of Industrial Junction Tower in Civil Engineering field. It comprises the important findings from the experimental works of many researchers. Due to over dependence on concrete is becoming an imminence and therefore it is necessary to look for the possibility of steel structure. Peoples in country like India it has been a mindset that only R.C.C building is long life, durable and withstand any forces.

1. To develop structure in Industrial Junction Tower using ETABS and fixing the model using restrains.
2. To use IS 1893:2002 standard code book, for evaluation of results under Response spectrum analysis.
3. To compare the designs in working stress method and limit state method.
4. To study the behaviour of industrial junction tower under earthquake forces.
5. To evaluate the performance of tower for different locations coming under the different seismic zones.
6. Best outcomes among the design elements needed to conclude by passing the minimum criteria of response spectrum, base reaction and response reduction factor.



II. RELATED WORK

Rajalakshmi et al. (2017) have planned, designed, and analysed the coal handling system's junction tower. Auto CADD, STAAD Pro software is used to plan, analyse, and design the Junction tower. This software is also used in the coal handling system for industrial sectors. Beams, Columns, Bracings, and Side Runners are all made of steel and are designed according to IS800 using Fe250 steel. The building's foundations are Isolated footing. The Plinth beam, Column head, and foundations are all made of RCC and are designed according to IS456 by the grade M20 and steel grade Fe415.

Prof. S.S. Patil and L.A. Pasnur compared the IS 800:1984 and IS 800:2007 methods for designing steel structures and found that for tension members, the Limit State Method (LSM) gives higher values than the Working Stress Method (WSM) or the Elastic method (EM). For Equal angle, it ranges from 12% to 50% as the section size goes from larger to smaller. For compression members, the strength increases as the section size goes up to a maximum of 15% in the Elastic method. So the limit state gives lower values than the elastic method. This paper came to the conclusion that the design of tension members using Angles by Limit state method (IS 800-2007) is cheaper than the working stress method (IS 800-1984), which has values between 12% and 54%. For compression members, the percentage increase in load carrying capacity as per IS 800-1984 is slightly higher than IS 800-2007, and the section fails if it is designed using IS 800-2007. So, the elastic method is cheaper than the limit state method for members that are under compression. INSDAG's website has information about how steel buildings can be made to withstand earthquakes. It has information about how structural steel, bracing members, and beam-columns behave in earthquakes (I sections, rectangular hollow sections, circular hollow sections, concrete filled tubes). In addition to these, there is some brief information about special devices and systems, such as laminated rubber bearing pads used to isolate the base and viscoelastic dampers and tuned mass dampers used to control vibrations.

Anitha M. and Divya K.K. did a study to compare how a steel knee-braced frame and an eccentric-braced frame react to earthquakes. This paper says that the beams and columns have a big effect on how a KBF structure moves sideways. The knee part will give way first, without affecting the other main parts of the structure. In a nonlinear static analysis, steel frames with double knee bracings behave very well when there is a strong earthquake. The highest load that can be supported by a double knee brace is higher than that of an eccentric brace. When compared to eccentric bracings, double knee bracings show more stiffness on the side.

Christopoulos et al (2008) Self-centering energy dissipating frames (SCEDs) are an advanced cross bracing system that has been used at the University of Toronto. Both special moment-resisting frames and buckling-reinforced braced frames get rid of energy, but special moment-resisting frames and buckling-reinforced braced frames can also put themselves back into place after a big earthquake.

E.M. Hines, C.C. Jacob, and others (2009) The performance of low-ductility steel systems made for regions with moderate earthquakes has renewed interest in designing cost-effective ductile systems for these areas. Even though eccentrically braced frames (EBFs) have a well-known reputation as systems with high ductility and have the potential to offer cost-effective solutions in moderately seismic areas, not much has been said about how well their systems work. Eccentrically Braced Frames (EBFs) are popular because they have a good mix of high elastic stiffness and good inelastic performance (AISC 2005).

K.G.Vishwanath(2010) "Seismic response of Steel braced reinforced concrete frames" was presented in the 2010 issue of the International journal of civil and structural engineering. IS 1893:2002 says that a four-story building was taken in seismic zone 4. Story drift is used to judge how well a building does its job. The study is then expanded to include eight and twelve stories. It turns out that X type of steel bracing works best.

K.K.Sangle, K.M. Bajori, and V.Mhalungkar did research on "Seismic Analysis of High Rise Steel Frame Buildings with and without Bracing" in 2012. The goal of the study was to compare the results of earthquake analyses of high-rise steel buildings with and without bracing systems. Using a method called "time history analysis," the study's results show that bracing elements will have a big impact on how a structure acts when an earthquake hits.



In 2008, S.H. Chao, M.R. Bayat, and others did research on performance-based plastic design of steel concentric braced frames for a higher level of trust in China. Concentrically braced frames (CBFs) are generally thought to be less earthquake-resistant than other systems because the braces buckle or break when large cyclic displacements are put on them. This is because CBFs are easier to build and work better than other systems like moment frames, especially after the Northridge Earthquake of 1994. S. Krishan., et.al. (2008). Modeling steel moment frame and braced frame buildings in three dimensions using FRAME3D. He worked on the development of steel frame buildings.

III. METHODOLOGY

3.1 Gravity analysis

Loads in constructive building design are taken into dead loads, live load. Earthquake load etc were applied.

3.2 Dead load

In the design of buildings the dead weight is assumed and it is given in the form of unit weight of material. The unit weight of other materials that can be stored in buildings is also considered for loading calculation. Dead loads are considered to be part of IS 875 Part 1.

3.3 Live load

In the design of buildings the live load is considered. It contributes to physical contribution due to individuals, furniture load and other equipment. This load consists of movable sections, distribution focused loads, impact and vibration loads, but excluding air, earthquake, snow loads and other loads. Live Loads IS 875 Part 2.

3.4 Load combination

When a structure is under earthquake forces the following combinations are considered as per limitation of the state including the design of structures of the reinforced concrete under the code book of IS 1893-2002

1. $1.5(DL \pm IL)$
2. $1.2(DL + IL \pm EL)$
3. $1.5(DL \pm EL)$
4. $0.9DL \pm 1.5LL$

Where the term DL, LL, and EL stands for the response quantity due to dead load, imposed load and designed earthquake load respectively.

3.5 Earthquake analysis

- Analysis in the linear static which is also known as the Equivalent static where we can study the lateral force method
- Analysis using the linear dynamic Methodology where the proper Response spectrum and its important method studied.
- Analysis using the Non-linear static Methodology where the study of the Pushover analysis
- Analysis using the Non-linear dynamic Methodology where the Time history and its important analysis can be studied.

3.6 Linear static analysis

Most of the time, this is caused by the movement of the structure during an earthquake. This dynamic analysis isn't used very often because it's hard to do and takes a long time. Most buildings that are subject to seismic forces are made with the idea that the building will be stretched to the point where it can't bend anymore.

In this method, the idea is that the static loads on the structures, in terms of their direction and size, are almost the same as the dynamic loads caused by the earthquake. When there is a lot of movement in the building, concentrated lateral forces will act at the ceiling, roof, and floor levels where there is a lot of mass.

3.7 Linear dynamic analysis

The static method is only used for short buildings, so the dynamic method is better for tall buildings with non-orthogonal or torsional irregularities. Models are made of the seismic input, but in both cases, the displacement and



internal forces are found by using linear elastic analysis. Unlike the linear static analysis procedure, the linear dynamic analysis procedure can use high modes.

3.8 Response spectrum analysis

This method uses the amount of damping and the history of time to measure the pseudo-spectral acceleration, displacement, or velocity of a structure to find out how it moves. For each structural period that the structure goes through, there is a smooth curve that shows the peak response in a response spectrum for the structure's dynamic response. This method has to do with choosing the type of structure. This method is useful for making decisions about how to design a structure. This method needs to follow a lot of building codes, except for simple structures or structures with a lot of parts. In a simple way, the response of a structure is defined as the combination of some modes in a string that vibrates, taking into account the corresponding harmonics and the computer software that is used to figure out these modes for a specific structure. The response is based on the mass and frequency of the mode, which is read from the spectrum of the design for each mode. So, the x, y, and z directions should be looked at, and then the effect on the structure. The combination method includes the following: This method isn't good for making an irregular structure, a tall formation, or a lot of people, so it can't be used to analyse situations like these.

3.9 Non-linear static analysis

This method is also called an analysis of the push-over. It tells us what the capacity curve is. It shows how forces work together. These forces are put on the structure, which has properties that don't follow a straight line. Then, the total force applied is plotted against a known displacement. The single degree of freedom, which is an important system because this curve can be combined with the demand curve, might help solve this problem. This method uses a single-degree-of-freedom system, and the results of the model and the analysis of the response spectrum show that it represents seismic ground motion.

3.10 Non-linear dynamic analysis

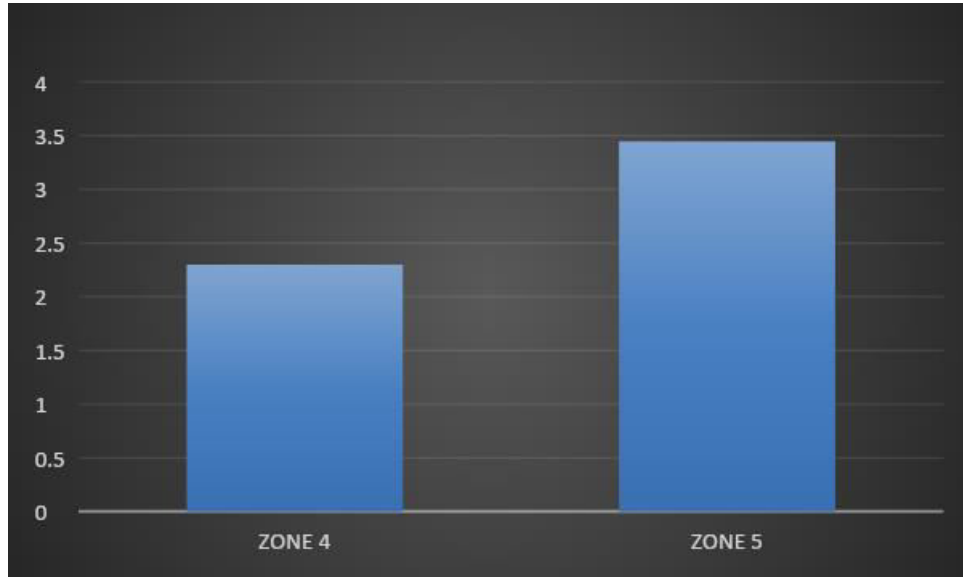
This method is a mix of details about the structure and the ground motion. Because of this, this method affects uncertainty less. In this way of analysing, the generalisation of the ground motion needs some codes for most of the analysis. To get structural response, you need to keep track of several different ground motion records.

As the amount of damage from an earthquake depends on how sensitive it is, the ground motion needs to be evaluated. This requires a nonlinear dynamic analysis to find out what could happen during an earthquake. All of these things make the rich dynamic analysis possible.

IV. EXPERIMENTAL RESULTS

DISPLACENEMT ALONG X AXIS

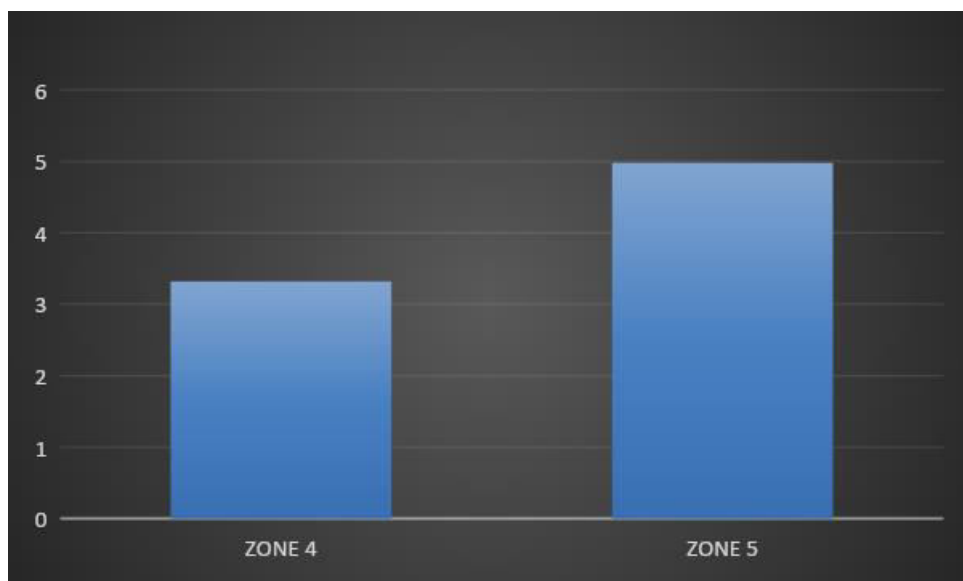
MODEL	X IN MM
ZONE 4	2.298
ZONE 5	3.446



In this Junction Tower Model in the X direction, the Displacement Loads Results for Zones 4 and 5 show that the displacement increases as the zone number goes up. So, considering the displacement along the X direction, Zone 4 is the safer zone for this model.

DISPLACENEMT ALONG Y AXIS

MODEL	Y IN MM
ZONE 4	3.321
ZONE 5	4.981

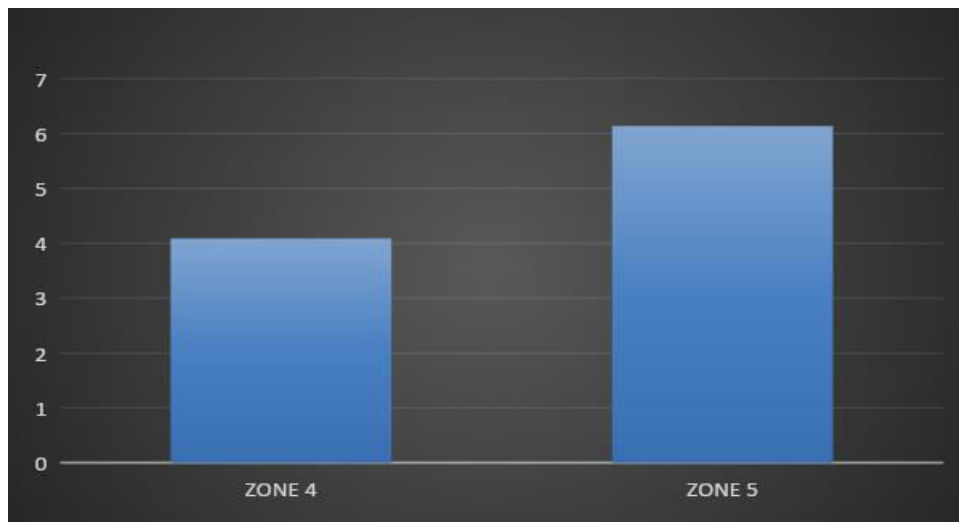


In this Junction Tower Model in the Y direction, the Displacement Loads Results for Zones 4 and 5 show that the displacement increases as the zone number goes up. So, considering the displacement along the Y direction, Zone 4 is the safer zone for this model.



STORY SHEAR ALONG X AXIS

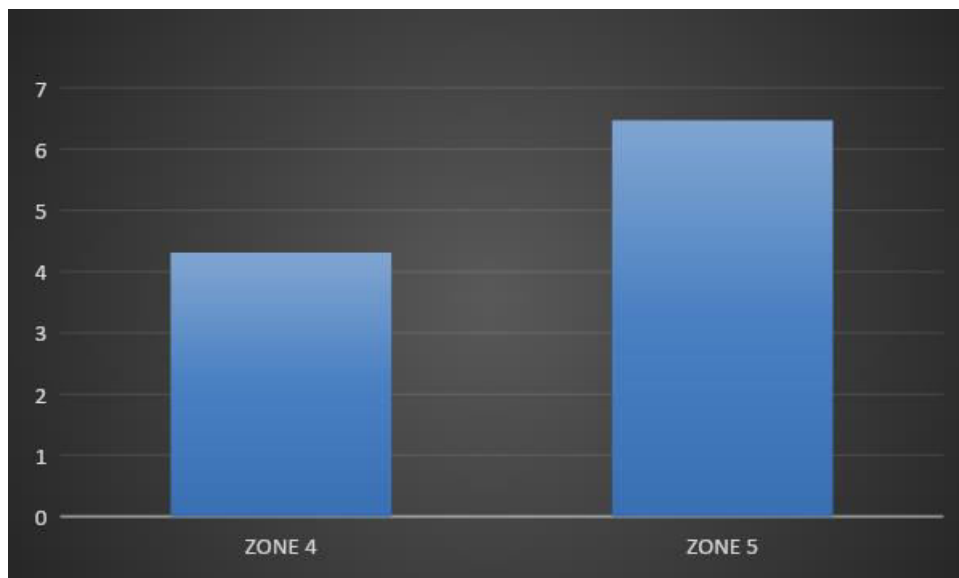
MODEL	Y IN MM
ZONE 4	4.0898
ZONE 5	6.1347



In this Junction Tower Model in the X direction, the results for the model at Zones 4 and 5 show that the story shear increases as the zone number goes up. So, considering the story shear in the X direction, Zone 4 is the safer zone for this model.

STORY SHEAR ALONG Y AXIS

MODEL	Y IN MM
ZONE 4	5.3894
ZONE 5	5.3894

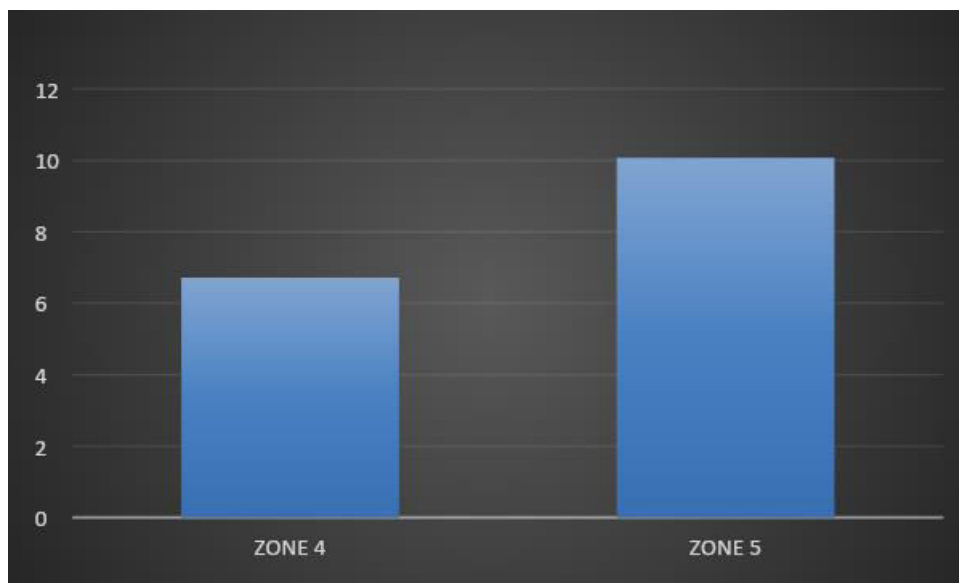




In this Junction Tower Model in the Y direction, the results for the model at zones 4 and 5 show that the story shear increases as the zone number goes up. So, considering the story shear in the Y direction, Zone 4 is the safer zone for this model.

AUTOLATERL ALONG X AXIS

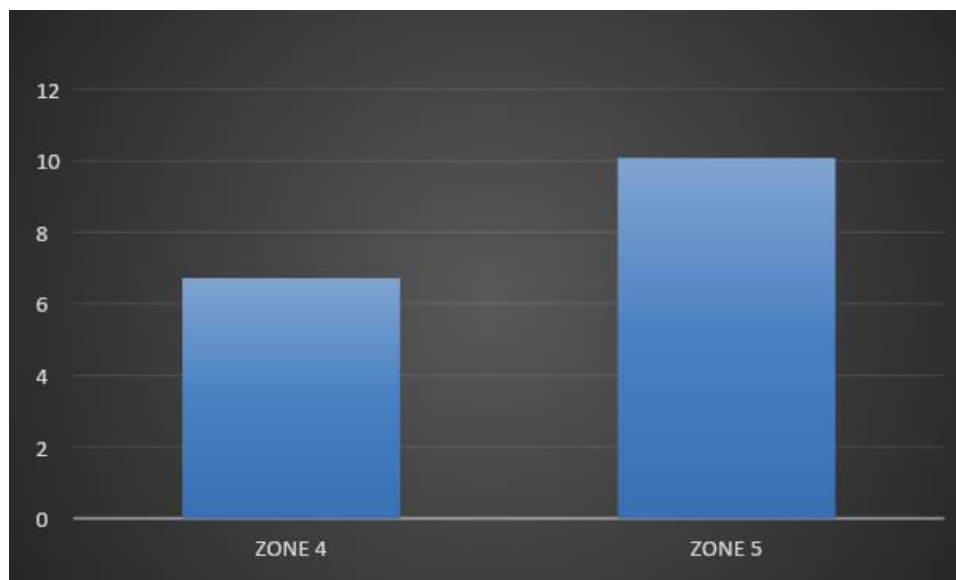
MODEL	X IN KN
ZONE 4	6.7165
ZONE 5	10.0747



In this Junction Tower Model in the X direction, the results for the model at zones 4 and 5 show that the story shear increases as the zone number goes up. So, considering the auto-lateral in the X direction, Zone 4 is the safer zone for this model.

AUTOLATERL ALONG Y AXIS

MODEL	X IN KN
ZONE 4	6.7165
ZONE 5	10.0747



In this Junction Tower Model in the Y direction, the Auto-lateral Loads Results for zones 4 and 5 show that the story shear increases as the zone number goes up. So, considering the auto-lateral along the Y direction, Zone 4 is the safer zone for this model.

V. CONCLUSION

In this Junction Tower Model, the results for zone 4 in the X direction are 2.298 mm, and the results for zone 4 in the Y direction are 3.321 mm. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis. In this Junction Tower Model, the results for zone 4 in the X direction are 4.0898 mm, and the results for zone 4 in the Y direction are 4.3115 mm. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis. In this Junction Tower Model, the results for zone 4 in the X direction are 6.7165 mm, and the results for zone 4 in the Y direction are also 6.7165 mm. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis. In this Junction Tower Model, the results for zone 5 in the X direction are 3.446 mm, and the results for zone 5 in the Y direction are 4.981 mm. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis. In this Junction Tower Model, the results for zone 5 in the X direction were found to be 6.1347 mm, and the results for zone 5 in the Y direction were found to be 6.4673 mm. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis. In this Junction Tower Model, in both the X and Y directions, the results for zone 5 are 10.0747 KN in the X direction and 10.0747 KN in the Y direction. And the curve along the X and Y axes is shown in the graph below with their respective colours, which makes it easy to compare for further analysis.

So, we can say that the Industrial Tower Design model is only strong enough to stand up in Zone 4. When we look at all of the results, it's easy to see that the life span of the Tower model changes as zone 5 grows. So, based on the results, it's better to think about the Tower model at Zone 4.

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